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FUEL EMISSIONS' CORRELATION ASSESSMENT OF INDOOR POLLUTANTS FROM DIFFERENT HOUSEHOLDS

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ABSTRACT

Air is rendered impure for respiration of man due to combustion of coal, gas, oil, traffic and manufacturing processes that give off dust, fumes, vapors and gases. The common indoor air pollutants are CO, NO_X, SO_X and particulate matter ($PM_{10,}$ $PM_{2.5}$ and $PM_{1.0}$). The present work is on exposure assessment of indoor air pollutants in different households for five different fuels i.e., Kerosene, Biomass, LPG, Cow dung cakes and Coal. Sampling stations were considered in and around Mysore city. Indoor concentration of NO_2, SO_2, SPM, RSPM and CO for all the fuels were monitored using Handy sampler, personal sampler and Gastec precision gas detection system respectively. Sampling before, during and after cooking was carried out for 2 hours. Higher NO_2 indoor concentrations during cooking were found to be 223.45µg/m^3 in households where coal is used as fuel, while min concentration of 158.34 µg/m^3 was found to be in LPG households using LPG. SO_2 was found to be as high as 167.34µg/m^3 in coal used households while low concentration was observed in LPG using households. SPM and RSPM were found to be high in biomass households (1438.5.µg/m^3 and 1484.89µg/m^3). High CO concentration of 30ppm was found during cooking period in coal used households. Pearson's correlation values for most of the parameters were found to be significant at 0.01 level. It was concluded that indoor air pollutants CO and RSPM are very closely correlated in most fuels, and have the impact on human health.

Keywords: Exposure Assessment; Indoor Air Pollutants; SPM; CO; SO_2: NO_2

1. INTRODUCTION & LITERATURE

Air is rendered impure for respiration of man and animals. Combustion of coal, gas, oil, traffic and manufacturing processes give off dust, fumes, vapors and gases. Researches on environmental conditions is disclosing a surprising and disturbing factor on human health is that the quality of air in our homes and offices is much more important than ever suspected. Environmental health researchers have discovered that indoor air is often two to five times more polluted than outdoor air, and can be up to thousand times more contaminated in extreme cases. Many of us spend up to 90% of our time in indoors. The health risks associated with indoor air quality far surpass the risks related to outdoor air contamination. The common indoor air pollutants are the combustion pollutants like CO, NO_2, SO_2 and particulate matter ($PM_{10,}$ $PM_{2.5}$ and$PM_{1.0}$). Increased indoor air pollution can occur because of poor air mixing in the stove especially when the stove is not well ventilated, with high concentration of above said indoor pollutants often exceeding the Indoor Air Quality Standards.

In developing countries, exposure to smoke is arguably the greatest indoor air pollution problem. About half of the world's population relies on biomass fuels (wood, agricultural residues, and charcoal) as the primary source of domestic energy; nearly 2 billion kg of biomass are burnt every day in developing countries (Barnes et al. 1994). In rural India, nearly 90% of primary energy use is accounted for by biomass (wood, 56%; crop residues, 16%; dung, 21%) (TEDDY, 1998). In a number of households, burning of wood, crop residues or animal dung is often undertaken without adequate ventilation. Due to incomplete combustion, the use of biomass fuel in traditional stoves produce high level of indoor air pollutants which is responsible for more than 1.6 million of deaths and 2.7% of global burden of diseases (WHO, 2006). Use of open fires with simple solid fuels, biomass, or coal for cooking and heating exposes an estimated 2 billion people worldwide to concentrations of particulate matter and gases that are 10 to 20 times higher than health guidelines for typical urban outdoor concentrations (Kalpana et al.2004). There is a growing body of evidence that poor air quality inside the houses, poses a serious threat to human health. Bioaerosols can cause a variety of respiratory diseases. These range from allergic rhinitis, asthma to infectious diseases such as histoplasmosis, balstomycosis and aspergillosis. The health effects of air borne particulates depend on several factors that include particle dimensions, durability and dose.

In India over the last two decades, a few dozen studies concerning indoor air pollution (IAP) levels/exposures associated with biomass combustion have been carried out. Some qualitative data on exposures, such as by primary fuel type, are routinely collected in national surveys such as the Census and National Family Health Survey, and serve as readily available exposure indicators, but they often lack precision for estimating household-level exposures. Although these efforts have convincingly shown that indoor pollution levels can be quite high compared to health-based standards and guidelines. The few studies that have been carried out in India, most are in northern Indian households. The information on exposures in southern Indian household is limited. The climatic and cultural differences between the northern and southern Indian regions have the potential to influence exposures significantly. Several studies concerning biomass combustion, air pollution, and health have been conducted in rural Indian villages (Awasthi et al., 1996).The burden of disease attributable to use of biomass fuels in India is estimated as 5–6%of the national burden of disease (Smith et al., 2000). As Indoor Air Quality Standards are not available in India, WHO Standards are used.

Although these estimates are reasonable for placing indoor air pollution as a major risk factor contributing to the national burden of disease, considerable uncertainty exists about the absolute magnitude of the health risks. Many studies have been conducted without considering the influence

of multiple exposure variables such as the type of fuel, type and location of kitchen, and type of stove on actual exposures. Use of surrogate exposure indicators without quantitative measurements and poorly defined illness outcome also results in considerable ambiguity in understanding the exposure–response relationship. In this scenario, current study focuses on correlation of pollutants with household fuels.

1.2 Objective

The main objective of this research work is to assess the exposure of occupants to indoor pollutants in different households by measuring Indoor concentrations.

Research approach: Indoor pollutants were monitored in selected households' Cooking area for a specific time period. These data were subjected to statistical analysis to know the correlation of fuel and pollutants. These correlations are used to establish relationship between indoor air pollutants and respiratory illnesses.

2. METHODOLOGY

2.1 Study Area

In the present work, western part of Mysuru city is considered as the study area. Mysuru is the second-largest city in the state of Karnataka, India. Located at the base of the Chamundi Hills about 146 km southwest of the state capital Bengaluru, it is spread across an area of 128.42 km^2. Mean Sea Level (altitude) of Mysore city is 765m, Latitude is 12.3024º N and Longitude is 76.6386º E.

2.2 Sampling Stations

The five sampling stations were considered randomly in and around parts of Mysuru city for five different fuels i.e., Kerosene, Biomass, LPG, Cowdung cakes and Coal in different households.

2.3 Sampling Procedure

Indoor sampling of pollutants is carried out for a particular time period of 2 hours before cooking, during cooking and after cooking for different fuels. The equipments used for monitoring SPM, NOx, and SOx in the indoor sampling are done using Handy Sampler (APM 821) and Personal air sampler (APS 2) is used for respirable suspended Particulate matter(RSPM) and CO is measured using Gastec precision gas detection systems.

2.3.1 Indoor Air sampling

Handy Sampler is the equipment used for indoor SPM, NO_2 and SO_2 sampling. The flow rate of 1.9 L/min is set in the pump. Personal Air Sampler is the equipment used for indoor RSPM sampling which consists of two parts pump and cyclone head. Initially flow rate of 1.9 L/min is fixed in the pump. The pre - weighed Whatman filter (Teflon) paper of 37mm diameter is placed in the filter cassette of the cyclone head. The sampler is switched on and sampling time is fixed for two hours before, during and after cooking period. Then the filter paper is weighed for the final weight. Using the following equations indoor concentration of PM is found,

Concentration of Particulate Matter,

C = (Final weight of filter paper – Initial weight) / V

Volume of air sampled, V = (Q/1000) * T

Where, T = Time period in hours

Q = Flow rate in m^3/min

Nitrogen oxides as nitrogen dioxides are collected by bubbling air through a absorbing solution sodium hydroxide to form a stable solution of sodium nitrate. The nitrate ion produced during

sampling is reacted with phosphoric acid, sulfanilamide and NEDA to form an azo dye and then determined colourimetrically by using spectrophotometer at 540nm wavelength.

SO_2 from air stream is absorbed in an absorbing solution sodium tetrachloromercurate, it forms a stable di-chloro sulphitomercurate. The amount of SO_2 is then estimated by the color produced when P-Rosaniline hydrochloride is added to the solution. The color is estimated by measuring spectrophotometer absorbance at 548nm.

3. RESULTS

This section presents the results of indoor pollutants concentration for the fuels considered in different households.

Figures 1 to 5 show the indoor SPM, NO_2, SO_2, CO and RSPM concentration for different fuels. The indoor SPM concentration in the biomass fuel household is very high when compared to coal and cowdung cakes which are also in higher than WHO Air Quality Guidelines (50μg/m^3 for 24h). The nitrogen dioxide concentration was found to be higher than WHO AQG Value (200 μg/m^3 for 1h) in biomass cowdung and coal used household, while SO_2 was found to be higher than AQG(500 μg/m^3 for 1h) value in kerosene and coal used household. The carbon monoxide was found to be higher than AQG in coal used household(30000μg m^{-3} for 1h). The indoor RSPM concentration in the biomass fuel household is very high when compared to WHO AQG (35 μg/m^3 for 24 h) other fuels; it is due to very low ventilation and incomplete combustion of the fuel.

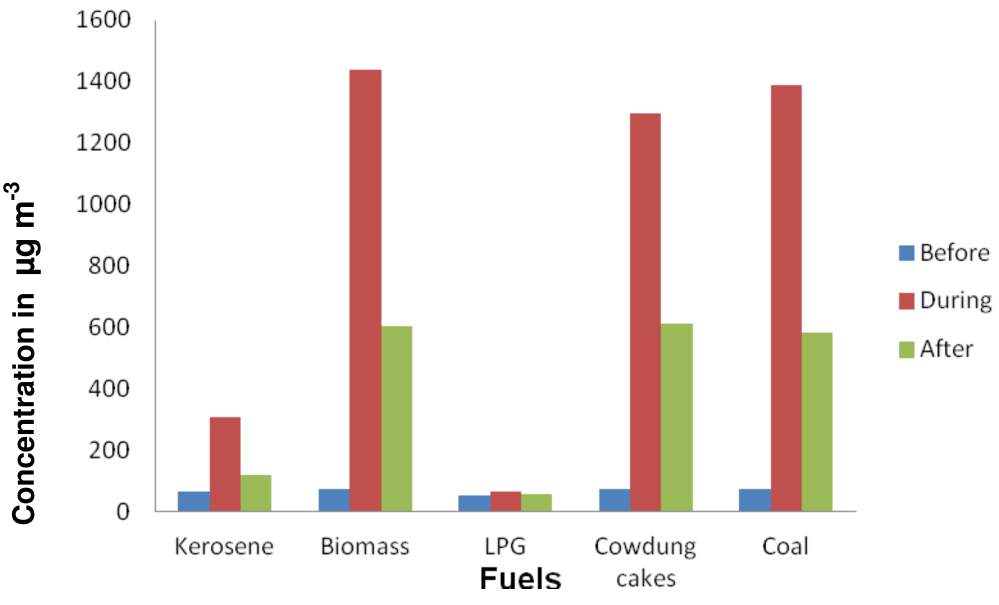

Figure 1: Indoor SPM emission in various household for different fuels

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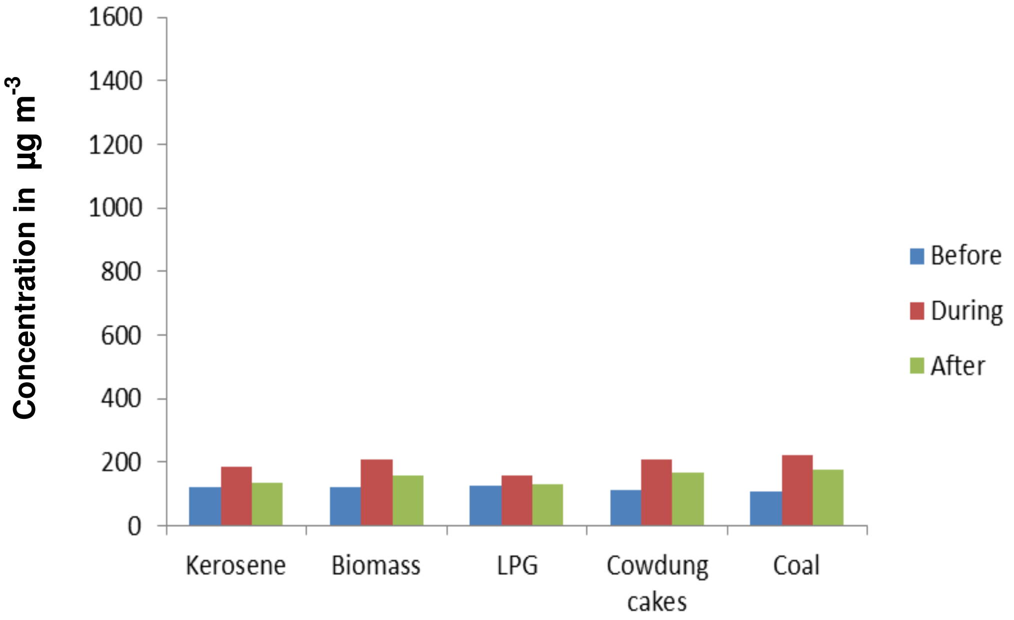

Figure 2: Indoor NO_2 Concentration in various household for different fuels

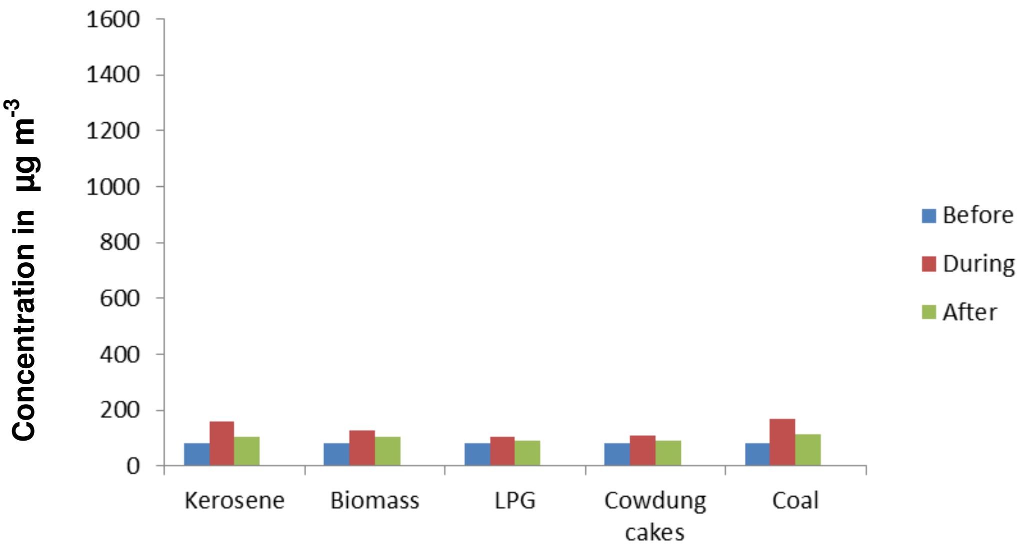

Figure 3: Indoor SO_2 Concentration in various household for different fuels

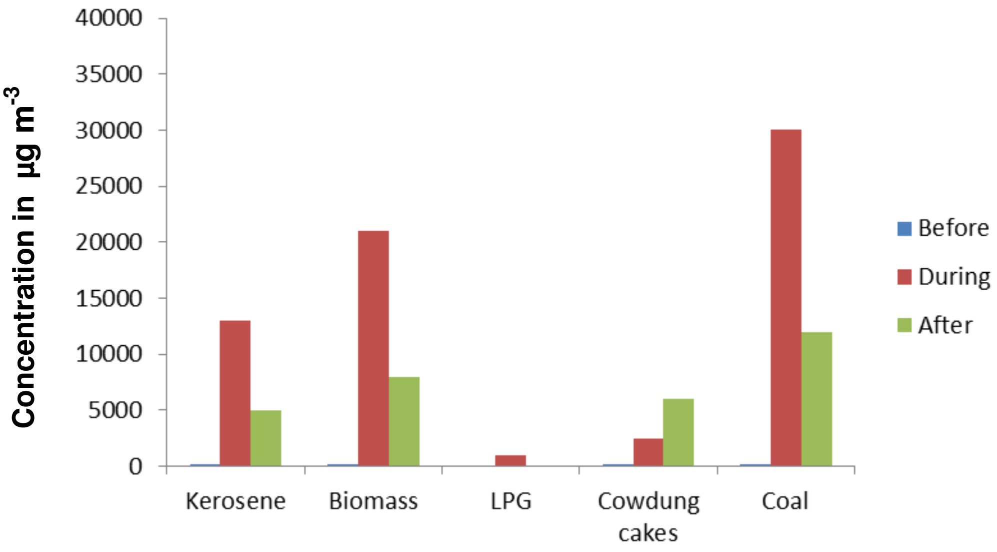

Figure 4: Indoor CO Concentration in various household for different fuels

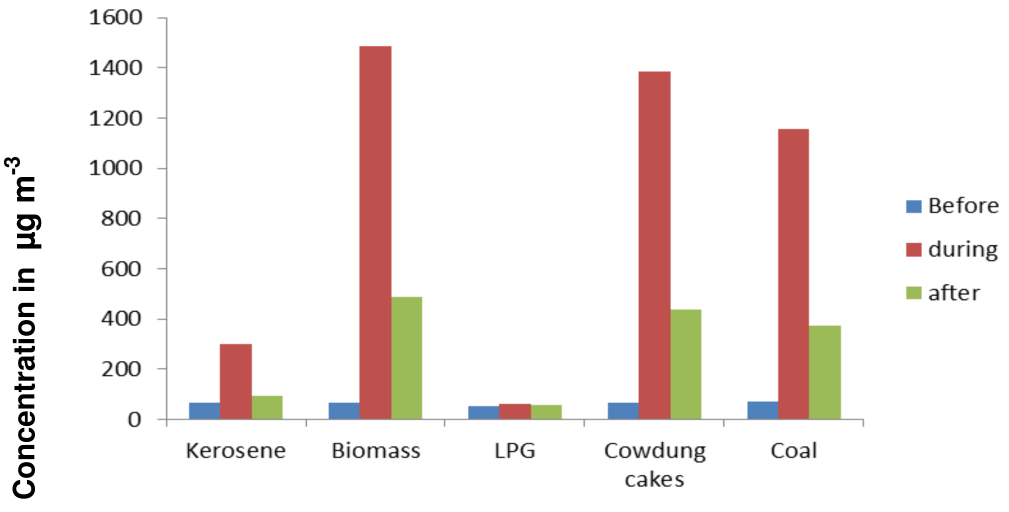

Figure 5: Indoor RSPM Concentration in various household for different fuels

Data collected during monitoring by the researcher. This data is purely fresh and belongs to the authors. The Pearson's correlation values of selected parameters for different fuels was obtained using SPSS16 version and is given in Tables 1 to 5. The monitored data was subjected to Pearson Correlation to verify whether the selected parameters of concern have close relationship with each other as well as with the fuel source. This is carried out at 2- tailed test. The obtained level of significance is 0.01.

Table 1: Pearson's Correlation values of selected parameter for Biomass fuel

Biomass	SPM	NO_2	SO_2	CO	RSPM
SPM	1	0.997839**	0.993517**	0.999928**	0.996454**
NO_2	0.997839**	1	0.996648**	0.998058**	0.990611**
SO_2	0.993517**	0.996648**	1	0.992902**	0.980444
CO	0.999928**	0.998058**	0.992902**	1	0.996834**
RSPM	0.996454**	0.990611**	0.980444	0.996834**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 2: Pearson's Correlation values of selected parameter for Cowdung cakes fuel

Cowdung cakes	SPM	NO_2	SO_2	CO	RSPM
SPM	1	0.99019	0.999117**	0.984359*	0.989639*
NO_2	0.99019**	1	0.984471	0.951858	0.960592
SO_2	0.999117**	0.984471	1	0.990716**	0.99447**
CO	0.984359*	0.951858	0.990716	1	0.999295**
RSPM	0.989639*	0.960592	0.99447**	0.999295**	1
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 3: Pearson's Correlation values of selected parameter for Coal fuel

Coal	SPM	NO_2	SO_2	CO	RSPM
SPM	1	0.984958	0.992738**	0.999875**	0.995278**
NO_2	0.984958	1	0.979239	0.986846	0.963574
SO_2	0.992738**	0.979239	1	0.992827**	0.98732
CO	0.999875**	0.986846	0.992827	1	0.994098**
RSPM	0.995278**	0.963574	0.98732	0.994098**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 4: Pearson's Correlation values of selected parameter for Kerosene fuel

Kerosene	SPM	NO_2	SO_2	CO	RSPM
SPM	1	0.995784**	0.990116**	0.981659	0.997104**
NO_2	0.995784**	1	0.997332	0.991043**	0.992586**
SO_2	0.990116**	0.997332**	1	0.998144	0.981869
CO	0.981659	0.991043**	0.998144**	1	0.969126
RSPM	0.997104**	0.992586**	0.981869	0.969126	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 5: Pearson's Correlation values of selected parameter for LPG fuel

LPG	SPM	NO_2	SO_2	CO	RSPM
SPM	1	0.525597	0.523676	0.602046	0.69107
NO_2	0.525597	1	0.995142**	0.97713*	-0.25137
SO_2	0.523676	0.995142**	1	0.954202*	-0.25167
CO	0.602046	0.97713*	0.954202*	1	-0.14077
RSPM	0.69107	-0.25137	-0.25167	-0.14077	1
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

From the pearson correlation tables, it can be observed that for almost all the selected parameters positive correlation has been obtained and the value of correlation in most of the cases 0.99. This indicates that the selected parameter are closely related with each other and are from the same fuel source. However, the correlation coefficient for fuel LPG are found to be negative, confirming that there is no well established correlation between the parameters of concern and the fuel source.

4. CONCLUSIONS

- The average NO_2 indoor concentrations during cooking were found to be high in households where coal is used as fuel whereas minimum concentration was found to be in LPG households.
- SO_2 was found to be high in coal used household while low concentration was again in LPG household.
- SPM and RSPM were found to be high in biomass households. High CO concentration was found during cooking period in coal used households.
- The data has been subjected to statistical analysis for its acceptance.
- According to data analysis, Pearson's correlation values for most of the parameters were found to be significant at 0.01 level.
- The selected parameters are closely related with each other and are from the same fuel source and have impact on human health.

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